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MAPPING AND PREDICTING COLOR RETENTION AND OTHER QUALITY TRAITS IN BLACK BEAN POPULATIONS

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INTRODUCTION

Dry edible beans (*Phaseolus vulgaris* L.) provide an economical, nutritious food source for millions of people around the world and are grown in a diverse variety of sizes, colors, shapes, and agronomic traits. In the United States, dry beans are commonly consumed as ready-to-eat canned products, which makes canning quality important to industry standards and consumer preferences. When black beans are processed for canning, they dramatically lose their dark coloration, which results in an undesirable, faded-brown, canned product. Although phenotyping is time and labor-intensive, genotypes with superior color retention have been identified that can enable genetic improvement of this key trait. This research seeks to improve color retention and canning quality via complementary improvements in genotyping and phenotyping, bypassing the current onerous phenotyping procedures. Mapping color retention and canning quality traits to the dry bean genome may allow marker assisted selection, while refining predictive models may be able to efficiently screen dry seed.

MATERIALS AND METHODS

Several recombinant inbred line (RIL) populations were developed from parental genotypes that showed extreme differences in color retention (Table 1). Once canned, breeding line B14311 has abysmal color retention, resulting in light brown beans, while B12724 and B10244 'Zenith' have outstanding color retention, resulting in dark black beans. Color and appearance scores of canned beans are determined by a trained sensory panel using separate 1-5 hedonic scales, where 1 is very unfavorable (light brown color or split beans, respectively) and 5 is very favorable (dark black color or fully intact beans, respectively). B14311 was selected as a parent common to both populations due to the combination of poor color score and relatively high appearance score. The high appearance scores reflect good seed coat integrity, demonstrating that color loss in this genotype is not necessarily due to mechanical breakdown of the seed coat. Recurrent parents B12724 and 'Zenith' have good appearance scores and excellent color scores, despite having different genetic backgrounds and potentially different mechanisms of color retention. Selecting only parents with similar appearance scores minimizes any potential confounding effect between color and appearance ratings.

Approximately 150 RILs from each population were advanced to the $F_{4:6}$ generation before being canned using a modified protocol developed by Hosfield and Uebersax (1980). In addition to panelists' evaluation of color and appearance, canned RILs will be weighed, photographed, and analyzed for texture. At submission of this article, DNA from each RIL is being extracted via a modified CTAB protocol for genotyping on the BARCBean6K_3 microarray (Song et al., 2015). Genotypic data will be used to create linkage maps, which will then be combined with canning data to map quantitative trait loci (QTL) for color retention and appearance. This study will attempt to identify new QTL and validate previous findings by Wright and Kelly (2011) and Cichy et al. (2014).

Table 1. Phenotypic comparison of parents used in the mapping populations.

	Agronomic Traits					Canning Traits	
	Yield	100 Seed Wt.	Days to	Lodging	Agron.	Appearance Score†	Color Score*
Parent	(cwt/acre)	(g)	maturity	(1-5)	Score	(1-5)	(1-5)
B14311	24.2	18.7	96	1.0	5.0	3.7	1.7
ZENITH	23.3	22.4	96	1.0	4.8	4.2	5.0
B12724	22.0	21.2	101	1.0	3.5	3.5	4.8

Parental lines have similar agronomic traits, but contrasting color retention. *Zenith and B12724 have excellent color retention, while B14311 has abysmal color retention. †Appearance scores measuring degree of splitting are similar among parents. This minimizes the confounding effect of seed coat mechanical failure as the cause of leaching. Data from MSU 2015 Standard Black Yield Trials (Wright and Kelly, 2015)

FUTURE DIRECTIONS

Imaging data of the RILs not only provides objective measurements of color components for QTL analysis, but also permits the generation and refinement of predictive models. Images of canned beans will produce models for color and appearance, which can then be compared to actual color and appearance scores of the panelists. Dry beans from each RIL will be subjected to visible and near-infrared reflectance spectroscopy (Vis/NIR) and hyperspectral imaging to refine predictive models for color, appearance, and texture that were previously developed by Mendoza et al. (2014, 2017). These models can then be validated by imaging dry seed of additional black bean lines. Select lines will be canned and phenotyped to determine the potential for phenomic selection of color retention and other canning quality traits in black beans.

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